Microbiological Aspects of Fish and Fishery Products

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Introduction:

Fish and fish are often considered favourite foods due to their deliciousness, high protein content, unsaturated fatty acid content, and omega-3 fatty acid content. However, fish quickly spoils after being caught due to the biological and chemical components and microbial load. After twelve hours, the putrefaction process will start because of the metabolic activity of bacteria, the activity of endogenous enzymes (autolysis), and the oxidation of lipids caused by chemical reactions. After the catch, fish are particularly susceptible to spoilage, and it is essential for human health and safety that high standards of fish quality must be maintained at every stage of the food chain, from capture to consumption. Freshness and quality of fish at each step of the fish production chain can help manufacturers make safe, high-quality, and healthy fish meats, giving them an exceptional price in Global demand.

Microbial invasion:

In living conditions, when fish are first introduced to the environment, they are exposed to a wide range of microorganisms, but the fish's immune system keeps bacteria away from growing in the muscle of the fish. Once the fish dies, its immune system breaks down, letting bacteria grow out of control. During storage, they move between the muscle fibres and into the flesh. But, very few bacteria got into the meat when it was stored in ice. Since only a small number of organisms actually get into the flesh, and most microbial growth happens outside, spoilage is probably caused by bacterial enzymes getting into the meat and nutrients getting out. Still, the types of microbes usually found in fish and fish products fall into two groups: I. microorganisms responsible for spoilage, II. microorganisms that cause disease, i.e., Pathogenic bacteria

Spoilage bacteria:

In spoilage, only a subset of these contaminants can colonize and multiply in large numbers. The spoilage association in aerobically preserved fish is generally composed of Gram-negative psychrotrophic non-fermenting rods. There are several bacterial species on the surfaces of fish. According to their development temperature range, all temperate water fish bacteria are classified as either psychrotrophs or psychrophiles. Psychrotrophs (cold-tolerant) bacteria can thrive at 0°C; their growth is most efficient around 25°C. Bacteria known as psychrophiles (cold-loving) thrive best at temperatures between 15°C and 20°C. The term "spoilage association" has been coined for such a microbial community, but the precise mechanism by which one bacterial group dominates another closely related group is not always fully understood. Thus, under aerobic iced storage, the flora is virtually entirely constituted of Pseudomonas sp. and S. putrifaciens. Gram-negative, fermentative bacteria (such as Vibrionaceae) are responsible for spoiling unpreserved fish. At room temperature (25oC), the microflora is dominated by mesophilic Vibrionaceae, especially if the fish are

taken in contaminated waters. Fish spoilage is mainly caused by microbial growth, which creates flavour-altering amines, biogenic amines, organic acids, alcohols, aldehydes, and ketones.

Internal fish tissue is often considered sterile, but the bacteria on the slime layer of the skin, gills, and gut would invade after the death of the fish. Factors such as high-water activity and low acidity (pH > 6) of fish contribute to the rapid proliferation of microorganisms, which cause negative changes in the fish's appearance, texture, taste, and odour, diminishing its quality. Fish muscle consists of proteins, lipids, carbohydrates, water, and amino acid components, such as trimethylamine oxide (TMAO), urea, taurine, creatine, free amino acids, and trace glucose. In addition to psychrotrophic, aerobic, and facultative anaerobic Gram-negative bacteria, such as Pseudomonas, Moraxella, Acinetobacter, Shewanella putrifaciens, Vibrio, Flavobacterium, Photobacterium, and Aeromonas, Gram-negative bacteria also contribute to fish spoilage.

Microorganisms develop spoilage chemicals during the preservation of fresh fish. Bacterial proliferation results in the formation of a slime layer, the darkening of the gills and eyes (in whole fish), and the loss of muscle texture (softened due to proteolysis). The volatile molecules produced by protein putrefaction cause odours such as fishy (due to trimethylamine) and spoilage. Numerous proteolytic and hydrolytic enzymes are produced by Pseudomonas putrifaciens, Pseudomonas fluorescens, and other spoilage bacteria when they proliferate and multiply fast. Pseudomonas fluorescens is responsible for fish's greenish-yellow hue, whereas Micrococcus, Bacillus and Sarcina are responsible for the yellow and red hues, respectively. Yeasts and moulds are responsible for the chocolate-brown hue, and Streptomyces for the musty stench.

Table: 1 Specific spoilage Organisms in the fish and fishery products:

Storage temperature	Packaging atmosphere	Dominating microflora	Specific spoilage organisms (SSO)
0°C	Aerobic	Gram-negative psychrotrophic, non fermentative rods *(Pseudomonas spp., S putrefaciens, Moraxella Acinetobacter)*	S. *putrefaciens* *Pseudomonas*
0°C	Vacuum	Gram-negative rods psychrotrophic or with psychrophilic characte (S. *putrefaciens, Photobacterium)*	S. *putrefaciens* *P. phosphoreum*

0°C	MAP	Gram-negative fermentative rods with psychrophilic character *(Photobacterium)* Gram-negative non fermentative psychrotrophic rods (1-10% of flora *Pseudomonas, S. putrefaciens)* Gram-positive rods (LAB 2)	*P. phosphoreum*
5°C	Aerobic	Gram-negative psychrotrophic rods *(Vibrionaceae, S. putrefaciens)*	*Aeromonas spp.* *S. putrefaciens*
5°C	Vacuum	Gram-negative psychrotrophic rods *(Vibrionaceae, S. putrefaciens)*	*Aeromonas spp.* *S. putrefaciens*
5°C	MAP	Gram-negative psychrotrophic rods *(Vibrionaceae)*	*Aeromonas spp.*
20-30°C	Aerobic	Gram-negative mesophilic fermentative rods *(Vibrionaceae, Enterobacteriaceae)*	Motile *Aeromonas* spp. *(A. hydrophila)*

(Courtesy: FAO fisheries technical paper – 348)

Pathogenic bacteria:

In addition to human non-pathogenic bacteria species and the natural microflora of aquatic habitats, pathogenic bacteria are prevalent in fish. According to the European Food Safety Authority, *Campylobacter, Salmonella, Yersinia, E. coli, and Listeria monocytogenes* are responsible for significant foodborne outbreaks across the globe. However, not all bacteria are linked to outbreaks of foodborne illness caused by the eating of contaminated fish and fish products. Meanwhile, *L. monocytogenes, Vibrio spp., Salmonella, Yersinia spp., and C. botulinum* are particularly interested. These pathogens have a broad distribution in aquatic habitats and are associated with significant death rates in people due to illnesses such as listeriosis, botulism, and *V. vulnificus* infection. Thus, along with the nutritional advantages of consuming fish, there is also a possible danger to human health.

Practices to reduce the microbial load:

Physical damage, such as scale loss, bruising, and gut bursting, increases the number of sites available for bacterial attack and spread. Furthermore, cortisol levels rise during prolonged stress, affecting fillet quality. After the catch, fish may be held in the vessel for a few hours or weeks in melting ice, cooled brine, or -2 °C saltwater. Inadequate circulation of chilled brines may lead to the localized anaerobic development of specific microbes and spoiling, accompanied by the formation of off-odours. Used refrigerated brines may be polluted with many psychrotrophic spoiling bacteria, and reusing them can enhance the cross-contamination

of other fish with these microbes. Increasingly, and mainly when fish is held on board for extended durations, freezing facilities (-18 °C) may be employed to preserve the harvest (if possible). Fish may be eviscerated before marine storage, which has pros and cons. Intestinal enzymes and gut bacteria may discolour, degrade, and off-flavour un-eviscerated fish. In eviscerated fish, the incisions reveal microbial-vulnerable flesh. When eviscerating at sea, remove all stomach contents and wash the corpse before refrigerating, icing, or freezing. Whether to gut the catch at sea depends on its size.